Build a "solar powered" clock — it's fun, educational, and even useful

By Carl Bussjaeger

Here's a good way to have some celestial summer fun, and it doesn't involve watching the Hale-Bopp comet or southern Californians shedding their earth containers. How about learning to tell time with a solar clock? This article will show you how to build one.

Solar clocks—or sundials—are just plain fun to use, not to mention to build. And if you are homeschooling, turning your child loose with these instructions and some cardboard may be a fun way to teach a few of the basics of longitude and latitude. He'll also learn a bit about geometry. And, of course, it is a nice introduction to telling time for youngsters.

Let's start by defining a few terms.

Sundial—A device for determining time of day by observing the changing length or direction of the shadow cast by a fixed object.

Face—The surface of a sundial where the shadow falls. As a minimum, it has some type of graduated markings to indicate time, and often includes ornamentation and mottoes.

Gnomon- The fixed, shadow-casting portion of a sundial.

Style- The edge of the gnomon which casts the part of the shadow that determines time. Often used synonymously with gnomon.

Latitude- Distance from the equator as measured in degrees. On a globe, latitude is represented by the horizontal lines.

Longitude- Distance from the prime (0) meridian as measured in degrees. On a globe, longitude is represented by the vertical lines running from pole to pole.

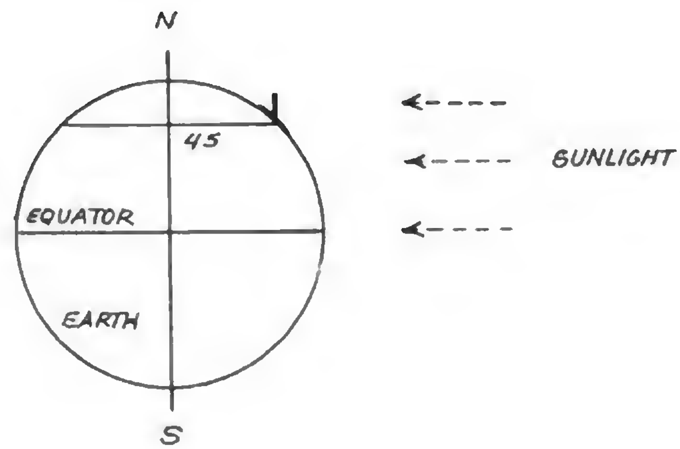

Figure 1. Aligning the style parallel to the earth's axis (dial at 45 degrees latitude)

General

In the following descriptions, the style on the sundial is always set at a certain angle determined by latitude. The reason for this is so the style will always be parallel with the earth's axis. Thus, the sun hits it squarely. A quick look at Figure 1 will demonstrate this.

This also shows why the style points north. Therefore, it is very important to know where true north is. This can be determined with a compass; but since magnetic north does not necessarily coincide with true north, you must know the angle of declination (compensation for true north) for your location.

If no compass is available, or if declination baffles you, despair not.

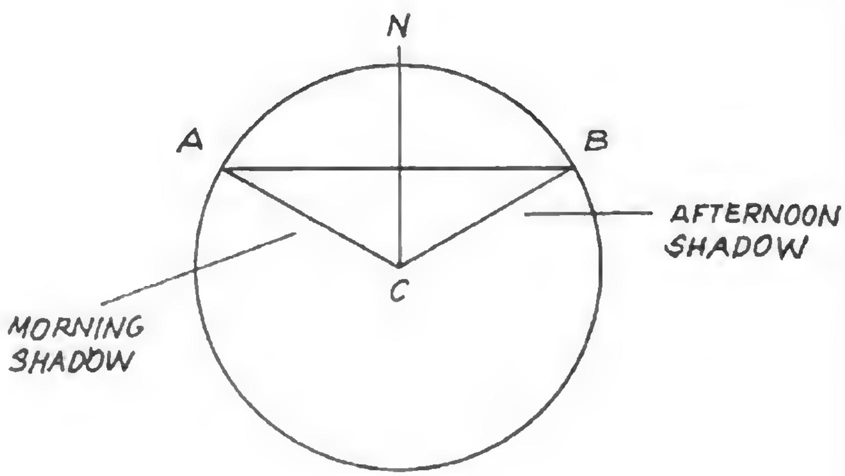

Figure 2. Finding true north

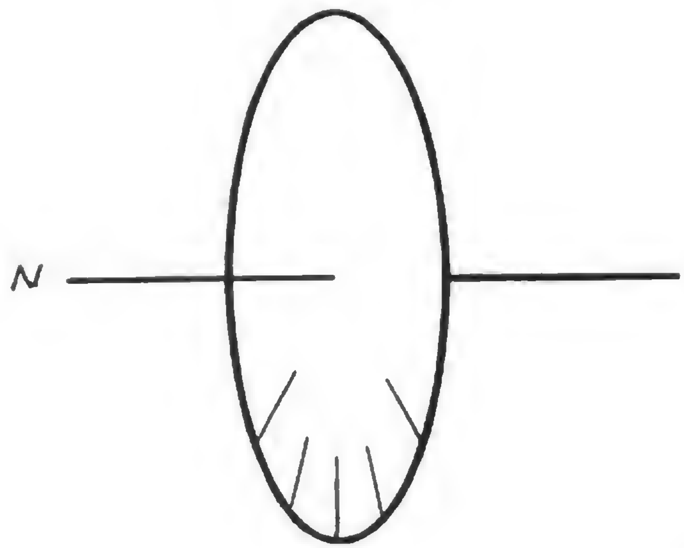

Figure 3. Equatorial sundial

Finding True North. On a level surface, draw a large circle. Set up a vertical rod at the center of the circle. On a sunny morning, watch the rod's shadow until the end of the shadow exactly touches the circle. Mark that point on the circle (A). In the afternoon of the same day, watch for the tip of the shadow to touch the circle again. Mark that point (B). Draw a line between the two points you have marked.

Now divide that line exactly in half with another line drawn from the center of the circle. This last line points to true north as in Figure 2.

Latitude and Longitude

Now, you know where north is. But where are you? You must know your latitude so you can properly orient the style on your sundial. Since relatively few people have the skills or the equipment to read their latitude from the sun (I certainly don't), or can afford LORAN receivers, cheat. Go to the library and look up your latitude on a U.S. Geological Survey map for your area. And while you're at it, scribble down your longitude as well. That information comes in handy later.

There are several different types of sundials you could build. I'll describe a few and leave it to you to decide which suits you.

The equatorial sundial

The equatorial sundial is one of the simplest of the dials. Take a long straight rod, stick it in the ground pointing north, and impale a circle on it. Mark the top of the face with evenly spaced hour marks. There you have it. The equatorial dial gets its name from the fact that, when properly aligned, the plane of the dial face is parallel with the equator as in Figure 3. It's done like this.

Face: Draw a circle. Starting with 0 degrees at the desired noon position, make hash marks on the circle at 15 degree intervals. Each 15 degrees indicates one hour. Half hour marks at 7.5 degree intervals, and quarter hour marks at 3.75 degree intervals, may also be added.

Style: The style is a straight rod set at the center of the circle, perpendicular to the face.

Alignment: The equatorial dial must be positioned so that the dial face is parallel with the plane of the equator and the style points north while elevated from the horizontal at an angle equal to your latitude. See Figure 4.

Problems: As the dial plane is parallel to the equator, the sun rises high enough to cast a shadow on top of the dial from only March to September. To make the dial useful for the rest of the year, mark the underside as well as the top. Unfortunately, for easy reading, this means the dial must be rather large. I've seen sundials of this type with faces as large as 8 feet across.

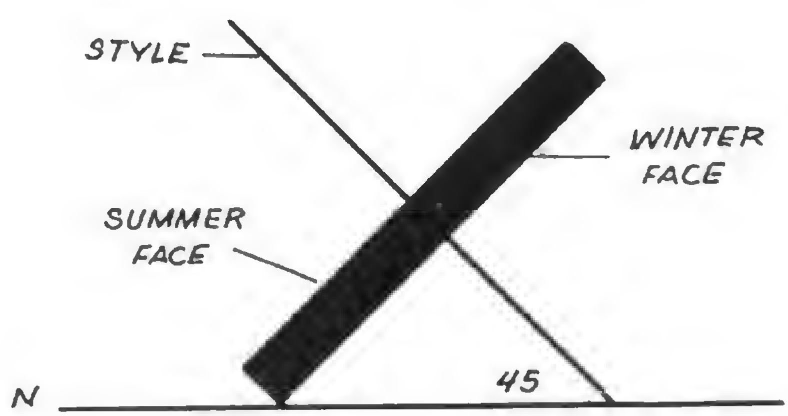

Figure 4. Equatorial dial aligned for 45 degrees latitude

Also, if your dial face is circular, your dial will have a tendency to roll around. You can get around this by making the bottom of the face a straight edge.

The polar plane dial

The polar plane dial is nearly as easy as the equatorial. This dial can be little more than a rectangle tipped to the north, and divided in the middle with a thin wall. See Figure 5.

With this dial, both the dial face and style are parallel to the earth's axis; hence the name.

Face: The dial is a plane aligned from east to west and tilted to the north at an angle equal to your latitude.

Style: The style is a plane rising perpendicularly from he dial face. It should be as long as the dial is wide, as in Figure 6.

Hour Marks: As in the equatorial sundial, the hour marks are made at 15 degree intervals. The marks will not be equidistant, however. The spacing will depend on the height of the style.

Line AB in Figure 7 represents the dial plane (face). Line CD represents the style. It must be the exact length of the actual style you will use. Beginning at point B, lay out a series of lines at 15-degree intervals. Where each line intersects line AB, make a mark. These are the hour marks. Half and quarter hour marks may be determined using 7.5 and 3.75 degree intervals, as before.

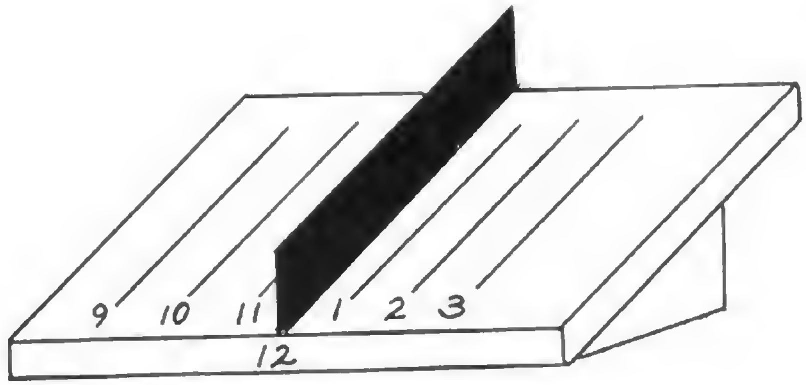

Figure 5. Polar plane sundial

The horizontal dial

The horizontal sundial shown in Figure 8 is the flat sundial with the angled style that many people imagine when they think of sundials.

Face: Marking the hours on a horizontal dial face is a little more involved than with the equatorial or polar plane dials.

Start with horizontal and vertical lines intersecting at point Y as in Figure 9. On the vertical line, at a convenient distance below Y, mark point Z. Line YZ will be the north-pointing noon line. Create angle YZW, which will equal your latitude (This angle can be thought oµf as representing the gnomon). Now create right (90 degree) angle YVZ. Draw a circle with the center (X) on the vertical line. The radius of the circle must equal the length of line YV (That is, the circle is twice as wide in diameter as line YV is long). Divide this circle into 15-degree arcs (I'll bet you knew 15 degrees would come into this eventually) with lines drawn from point X to your horizontal line. Mark these intersection points on the horizontal line A, B, C, and D. Draw lines from these points to point Z. These lines are the morning hour marks for the face of your sundial. The afternoon lines may be created the same way, or you can simply measure the intervals between the morning points and draw a mirror image of the morning lines.

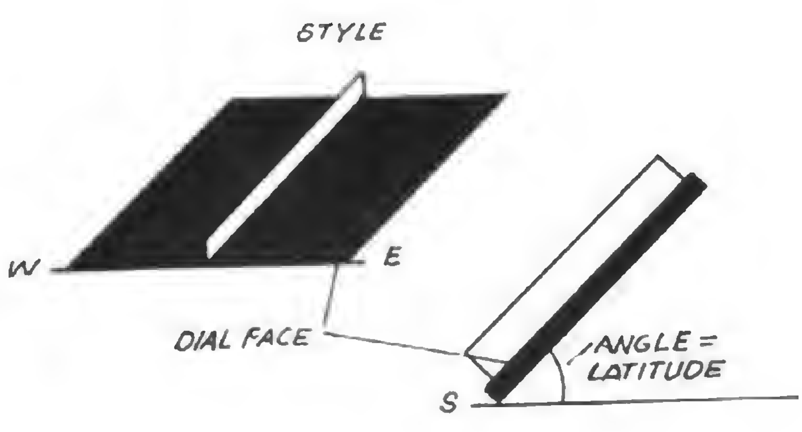

Figure 6. Alignment of a polar plane dial

Again, half and quarter hour lines can be determined using 7.5 and 3.75 degrees, respectively.

Style: As can be seen from the above description, the style angle equal to your latitude, and pointing north (Is this starting to sound familiar?). It should be aligned on the north-south noon line on the face.

South facing vertical dial

This sundial, shown in Figure 10, is remarkably similar to the horizontal

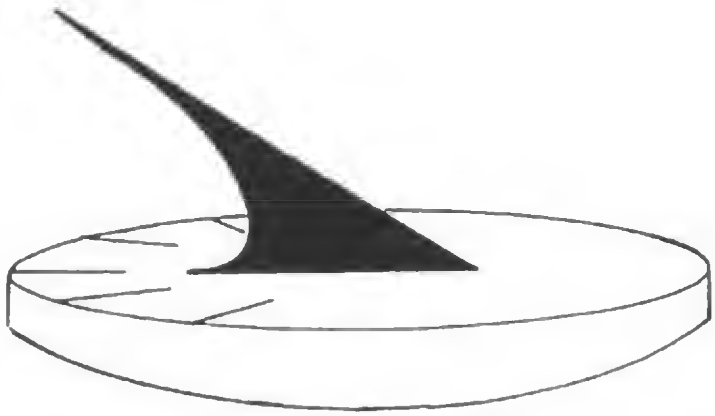

Figure 7. Creating the time marks for a polar plane sundial

dial except that it is mounted vertically on a south facing wall.

Here's how it's made.

Face: Follow the same procedure used for horizontal dials, except that angle YZW is equal to your co-latitude. Co-latitude is found by subtracting latitude from 90 degrees. For example; if your latitude is 30 degrees, then your co-latitude is 60 degrees.

Style: This time the style is at an angle from the vertical equal to your co-latitude, aligned on the noon line, and pointing down.

While vertical dials which face in virtually any direction can be made, their usefulness is limited in that they will be illuminated only at certain times of the day or year. So face it to the south for the best effect.

Construction Tips:

Obviously, for the sake of accuracy, you want to be quite careful when making measurements. When making the hour marks, remember that fine, precise lines are easier to tell time from than thick, precise lines.

If a very thick gnomon is used it can throw off the accuracy of the sundial. Try to keep it thin. If you cannot, remember to base your angle on the closest edge of the gnomon when preparing the hour marks as shown in Figure 11.

What time is it really?

You now know how to build a sundial that tells local time quite well. But local time is based on noon being when the sun is directly overhead. With modern standard time noon for an entire time zone is based on noon at a particular longitude; not necessarily yours.

Don't panic. You can make a sundial read standard time. First, find out what longitude standard time is based on in your time zone. Heck, let's cheat. I'll tell you.

Zone	Longitude
Atlantic	60 degrees
Eastern	75 degrees
Central	90 degrees
Mountain	105 degrees
Pacific	120 degrees

Notice the 15 degree intervals. Look familiar? Multiply 15 degrees by 24, which just happens to be the number of hours in a day. You get 360 degrees; which is the total arc of a circle—which is all the way around the Earth. Now you can see why we've been using 15 degrees all this time.

Okay, moving right along. Dig out your local longitude (You did scribble it down, didn't you?). Now, find the difference, in degrees, between your longitude and that on which your time zone is based. For example; Macon, Georgia is located at approximately longitude 84 degrees west. Being in the eastern time zone (75 degrees), the difference is 9 degrees west.

If you are putting together an equatorial sundial, you need to shift all your time marks by that many degrees. If you live to the west of the time zone base longitude, shift the marks to the east (or clockwise). If you live to the east of the base longitude, shift your marks to the west (or counterclockwise).

For polar plane, horizontal, and vertical sundials the compensation is not made in the time marks themselves, but in the 15 degree angles the marks were figured from. For instance, in figure 7, when measuring the 15 degree angles from line CD, shift them all by the required number of degrees.

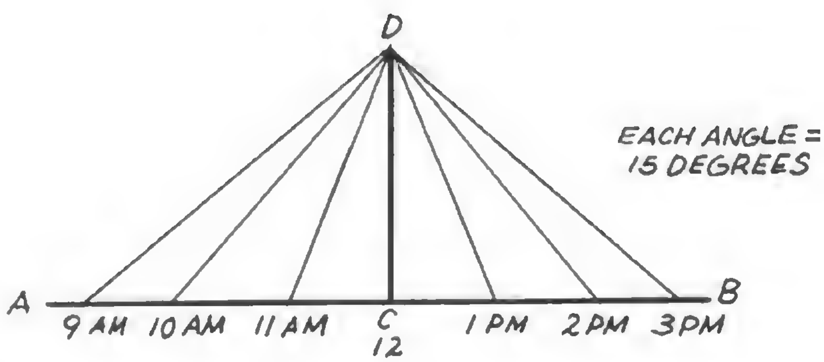

Figure 8. Horizontal sundial

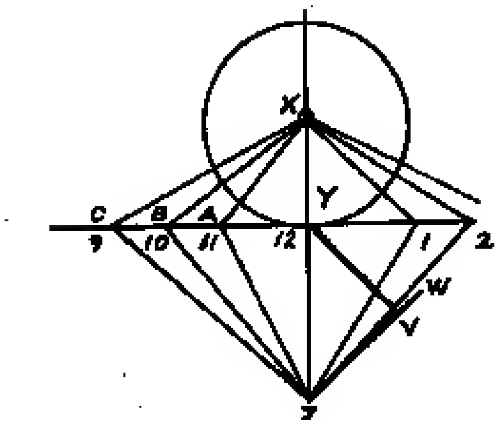

Figure 9. Creating time marks for a horizontal sundial

Simple, eh?

Making adjustments

Finally, your sundial reads standard time. Whaddaya mean we're on daylight saving time, now?

No problem. Make another sundial. Or you might consider some type of movable hour labeling for the fixed time marks. For a circular equatorial sundial this could be a rotatable outer ring with the numbers on it. For polar plane, horizontal, and vertical sundials you will probably have to settle for labeling each hour mark twice. Once each for standard time and daylight saving time.

But I want to take my sundial to events at different places.

We can make it happen. Two things are needed; some way to offset for latitude and longitude shifts. Latitude shifts are easy. For equatorial and polar plane dials all you need is a face mount that will allow you to vary the face's angle from horizontal. For horizontal and vertical dials, the angle of the gnomon must be variable (hmm, could the gnomon be a straight-edge mounted to a base with a thumb screw?).

Changes in longitude are just about as simple. For equatorial, horizontal, and vertical dials make your time marks on a circle that will pivot about its center so that you can offset the marks in the same way that you shifted the marks to make your dial read standard time. On a polar plane dial you will need a sliding bar for the time marks, rather than a rotating circle.

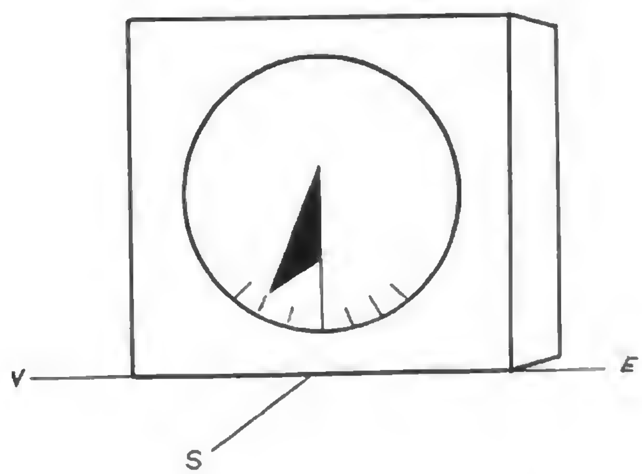

Figure 10. Vertical sundial mounted on a south-facing wall

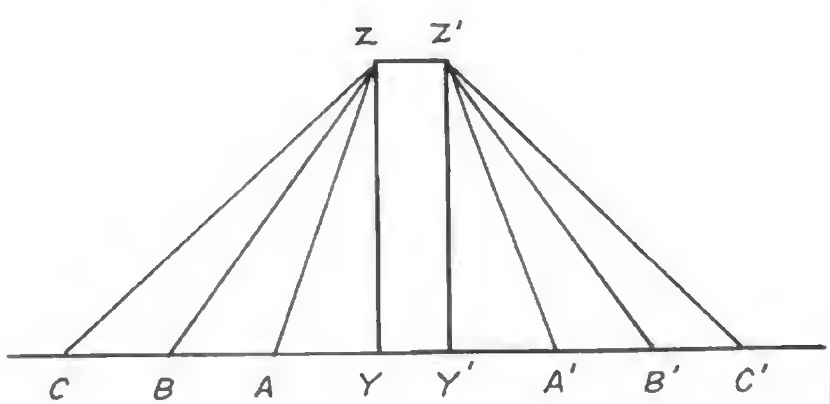

Figure 11. Creating time marks based on a very thick gnomon

The actual mechanics of construction I leave to your imagination and creativity, along with the question of ornamentation.

Whaddaya mean the sun's down now? I don't know; hmm, maybe candles with incremented bands of color... D